

Initiatives toward Open RAN

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Abstract

The fifth-generation mobile communications system (5G) network will need to support a wide range of services compared with past networks. To meet this need, it will be necessary to construct a flexible network that can accommodate all types of services. The Open Radio Access Network (RAN) can make this a reality. This article provides an overview of Open RAN, presents the current state of the O-RAN ALLIANCE that promotes Open RAN standards, and describes the 5G Open RAN Ecosystem, a new NTT DOCOMO Open RAN initiative.

Keywords: vRAN, virtualization, Open RAN

1. Introduction

To respond in a more suitable manner to customer needs, all mobile operators are required to add new network equipment and replace equipment to expand network functions on a continual basis. The network will therefore have to be capable of such scalability in a flexible and agile manner. To this end, NTT DOCOMO has been promoting open interfaces that will enable operators to freely select and adopt optimal solutions from a variety of vendor products.

This article provides an overview of the Open Radio Access Network (RAN)^{*1} and touches on the current state of the O-RAN ALLIANCE. It also describes the 5G (fifth-generation mobile communications system) Open RAN Ecosystem launched by NTT DOCOMO to globally accelerate Open RAN and the approach that it takes to solve problems related to performance, integration^{*2}, and interoperability testing in Open RAN.

2. Open RAN

2.1 Three elements of Open RAN

Open RAN consists of the following three elements (Fig. 1):

- (1) Open interfaces that combine RAN equipment from a variety of vendors
- (2) Virtualization (i.e., virtualized RAN (vRAN))

that enables hardware and software inside RAN equipment to be separated

- (3) Intelligent control that optimizes and automates RAN operation

2.2 Effects of Open RAN

The base-station components for Open RAN can be separated into three units—radio unit (RU)^{*3}, distributed unit (DU)^{*4}, and central unit (CU)^{*5}—each of which can be connected via standardized interfaces. This means that telecom operators can free themselves from vendor lock-in, shorten the time to commercial deployment, and adopt a better equipment configuration to provide optimized services to consumers. The virtualization of a RAN means that costs can be decreased through the use of general-purpose hardware and that flexibility and scalability can be enhanced. Envisioning an increasingly complex mobile network, manual operation of the network as has been the practice will become all the more

*1 RAN: A network consisting of radio base stations and other equipment situated between a core network and mobile terminals to control the radio layer.

*2 Integration: The process of incorporating equipment and systems into a network managed by an operator.

*3 RU: The radio unit of a wireless base station.

*4 DU: A component of a base station, the node that processes radio signals and transmits and receives radio waves.

*5 CU: Equipment that connects to the baseband unit and controls radio resources.

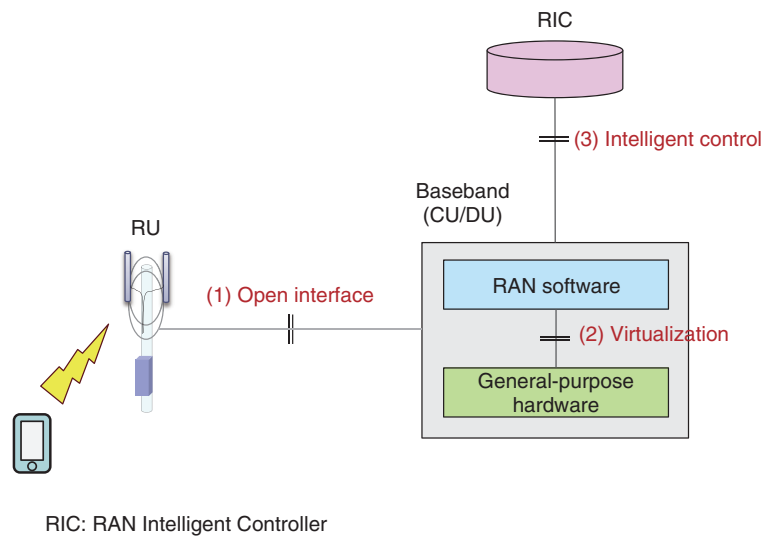


Fig. 1. Main elements of Open RAN.

difficult, but this problem can be solved through the intelligent control of a RAN.

3. Current status of Open RAN standardization

In February 2018, NTT DOCOMO joined with other industry operators to establish the O-RAN ALLIANCE with the aim of promoting open and intelligent RANs [1]. We introduce new initiatives of this organization from 2019 to the present.

There were 19 operators and 55 vendors and institutions serving as members of the O-RAN ALLIANCE in 2019, but this has expanded to 31 operators and 294 vendors and institutions as of February 22, 2022.

While only fronthaul^{*6} specifications from Work Group 4 (WG4) had been released in 2019, new specifications had been released from each WG and Focus Group (FG) as of February 22, 2022. We introduce newly released specifications from WG4 and WG5 for which NTT DOCOMO has been serving as co-chair.

In WG4, in addition to fronthaul specifications consisting of the control, user and synchronization plane (CUS-Plane) and management plane (M-Plane), the following three types of specifications have been released with version upgrades already being made.

Test specifications:

- Open Fronthaul Conformance Test Specification
- Fronthaul Interoperability Test (IOT) Specification

Cooperative transport interface (CTI) specifications:

- Fronthaul CTI Transport Control Plane Specification

In constructing Open RAN, testing must be conducted to confirm whether equipment from different vendors conforms to the interface specifications of the O-RAN ALLIANCE and whether multi-vendor connections can be made.

In WG5, the following specifications were released with version upgrades being made.

X2^{*7} specifications:

- New Radio (NR)^{*8} control plane (C-plane) profile
- NR user data plane (U-plane) profile

Transmission path specifications:

- Transport Specification

Monitoring control specifications:

- O1 Interface specification for O-CU-UP and O-CU-CP

*6 Fronthaul: In a radio base station, the interface for the optical-fiber link connecting the baseband processing section that executes digital signal processing and the RUs that transmit and receive radio waves.

*7 X2: A reference point between eNodeB (base station for Long-Term Evolution (LTE) radio access) defined by the 3rd Generation Partnership Project (3GPP).

*8 NR: A radio system standard formulated for 5G. Compared with 4G, it enables faster communication by using high-frequency bands (e.g., 3.7- and 28-GHz bands), and low-latency and highly reliable communication for achieving advanced Internet of Things.

Table 1. O-RAN ALLIANCE technology study groups.

	WG/FG	Scope of study
WG1	Use Cases and Overall Architecture	Architecture, use cases, slicing, demonstrations
WG2	Non-real-time RIC and A1 Interface	Non-real-time RIC, A1, rApp
WG3	Near-real-time RIC and E2 Interface	Near-real-time RIC, E2, xApp
WG4	Open Fronthaul Interfaces	Fronthaul
WG5	Open F1/W1/E1/X2/Xn Interface	Interoperability profiles such as X2, Xn, and F1; O1 to DU and CU
WG6	Cloudification and Orchestration	O-Cloud, vDU/vCU, AAL, O2
WG7	White-box Hardware	Mainly RU-hardware reference design
WG8	Stack Reference Design	DU/CU software-architecture reference design
WG9	Open X-haul Transport	Transport equipment, transport-network control/maintenance protocol
WG10	OAM for O-RAN	SMO, O1 (overall coordination)
SFG	Security	Security risk analyses and countermeasure studies for Open RAN
TIFG	Test & Integration	Compile test specifications, plugfest, OTIC, certification and badging processes
OSFG	Open Source	O-RAN Software Community
SDFG	Standard Development	Standardization strategies, interface to other standard development organizations

AAL: Acceleration Abstraction Layer
 OAM: operation and maintenance
 OTIC: Open Testing and Integration Centre

rApp: Non-real-time RIC application
 SMO: Service Management and Orchestration
 xApp: Near-real-time RIC application

- O1 Interface specification for O-DU IOT specifications:

- Interoperability Test Specification

To make intelligent Open RAN a reality, a number of new WGs and FGs have been established. **Table 1** summarizes the WG/FG activities.

The WGs and FGs that have been added since the founding of the O-RAN ALLIANCE in 2018 are WG9, WG10, Security FG (SFG), Test & Integration FG (TIFG), Open Source FG (OSFG), and Standard Development FG (SDFG).

Security concerns, in particular, have been raised as a key issue in Open RAN, and at the O-RAN ALLIANCE, SFG is conducting security risk analyses and countermeasure studies.

4. NTT DOCOMO Open RAN initiatives

4.1 NTT DOCOMO multi-vendor network initiative

In conventional networks, a single vendor provides base stations for both baseband signal processing units (BBUs) and RUs in a single-vendor configuration. One advantage of having a single vendor is that the operator can rely on that vendor for a range of services from deployment to maintenance in a one-stop manner. Since the interfaces between equipment are vendor-proprietary interfaces, a disadvantage is that the operator cannot upgrade to equipment from

other vendors, decreasing flexibility.

NTT DOCOMO took the lead in achieving a multi-vendor network before the coming of 5G. Specifically, NTT DOCOMO enabled connections between different vendors by prescribing original interfaces between the BBU and RU, achieving a flexible base-station configuration (**Fig. 2**). Since there were now multiple options for selecting base-station-equipment vendors, it became possible to select the most optimal vendors in terms of cost and performance, lowering the cost of deploying equipment.

4.2 NTT DOCOMO Open RAN initiatives in 5G

When launching 5G commercial services in 2020, NTT DOCOMO was the first in the world to achieve Open RAN in a commercial network using interfaces conforming to O-RAN ALLIANCE standards. All 5G base stations that NTT DOCOMO is now rolling out conform to O-RAN ALLIANCE fronthaul and X2 specifications. Since this is Open RAN, NTT DOCOMO has been gradually expanding equipment vendors and the variation in equipment ever since the 5G pre-commercial service period.

Specifically, NTT DOCOMO has come to support millimeter-wave (mmW)^{*9} capabilities, sub-6^{*10} inter-band carrier aggregation (CA)^{*11}, and stand-alone

*9 mmW: Radio signals in the frequency band from 30 to 300 GHz as well as the 28-GHz band targeted by 5G all of which are customarily called "millimeter waves."

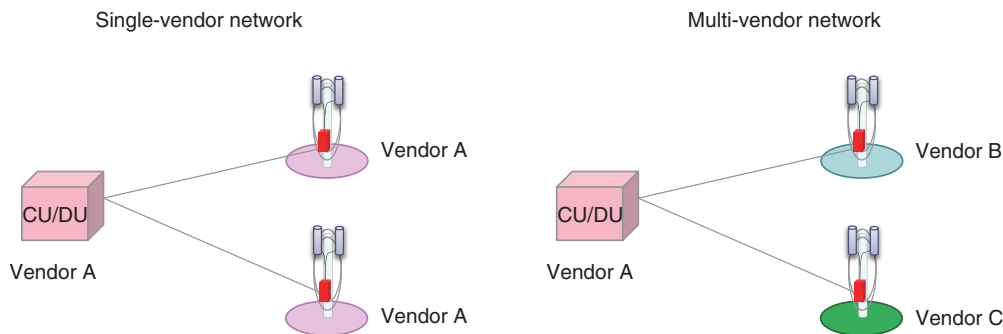


Fig. 2. Single-vendor and multi-vendor networks.

(SA)^{*12} operation. While only small RUs (SRUs) for small-cell use of both the antenna-separated and antenna-integrated types were deployed at the launch of 5G commercial services, NTT DOCOMO has since expanded the equipment lineup to include regular power RUs (RRUs) for macrocell use and 5G fronthaul multiplexers (FHM)s^{*13}. NTT DOCOMO is therefore adopting new vendors for CU/DU and RU.

NTT DOCOMO considers its multi-vendor initiative between equipment through open interfaces that it has been implementing as being its first step in Open RAN deployment. As the next step, it will promote studies on achieving the remaining two elements of Open RAN described above, i.e., virtualization and intelligent control (Fig. 3). This will be achieved through NTT DOCOMO's 5G Open RAN Ecosystem initiative described in the next section.

5. Promoting Open RAN across the globe

5.1 Founding of 5G Open RAN Ecosystem

In February 2021, NTT DOCOMO established the 5G Open RAN Ecosystem together with 12 other companies with the aim of accelerating the adoption of Open RAN by operators. Through this ecosystem, NTT DOCOMO aims to accelerate vRAN testing. It also intends to make state-of-the-art RAN into a commercial package based on the requirements of mobile operators that are studying the introduction of Open RAN and to offer Open RAN deployment, operation, and maintenance services. By making use of the Open RAN knowledge it has built up over many years, NTT DOCOMO will work to promote the 5G Open RAN Ecosystem and provide high-quality and flexible networks.

5.2 Open RAN problems and solutions

As described above, Open RAN has advantages but also has a number of problems that must be solved. We give an overview of the main problems in deploying Open RAN and describe how the 5G Open RAN Ecosystem plans to solve these problems.

(1) Performance

In vRAN, one of the elements of Open RAN, general-purpose servers are used as hardware, but when running RAN applications on such servers, radio characteristics, accommodation capacity, etc. may deteriorate. As a solution to this problem, end-to-end (E2E) vRAN testing using an accelerator is being promoted within the 5G Open RAN Ecosystem to achieve performance 2–3 times that of current performance. The 5G Open RAN Ecosystem Whitepaper including these performance targets was released in June 2021, so we ask the reader to refer to that material as well [2].

(2) Integration

In Open RAN, base-station components can be separated, but an issue that arises is how to integrate those components. In vRAN, hardware and software can be separated, so it is believed that components from different vendors can be integrated and provided accordingly. In this case, the number of interfaces needed for integration increases compared with conventional RAN. As a solution to this problem, an Open RAN testing environment, which is described

*10 Sub-6: A radio signal with the frequency band between 3.6 and 6 GHz.

*11 CA: A technology for increasing bandwidth by simultaneously transmitting/receiving signals using multiple component carriers.

*12 SA: Stand-alone format. A form of mobile communication network on which terminals connect using a single wireless technology.

*13 FHM: Equipment that multiplexes multiple fronthaul lines between the baseband processing section and radio equipment.

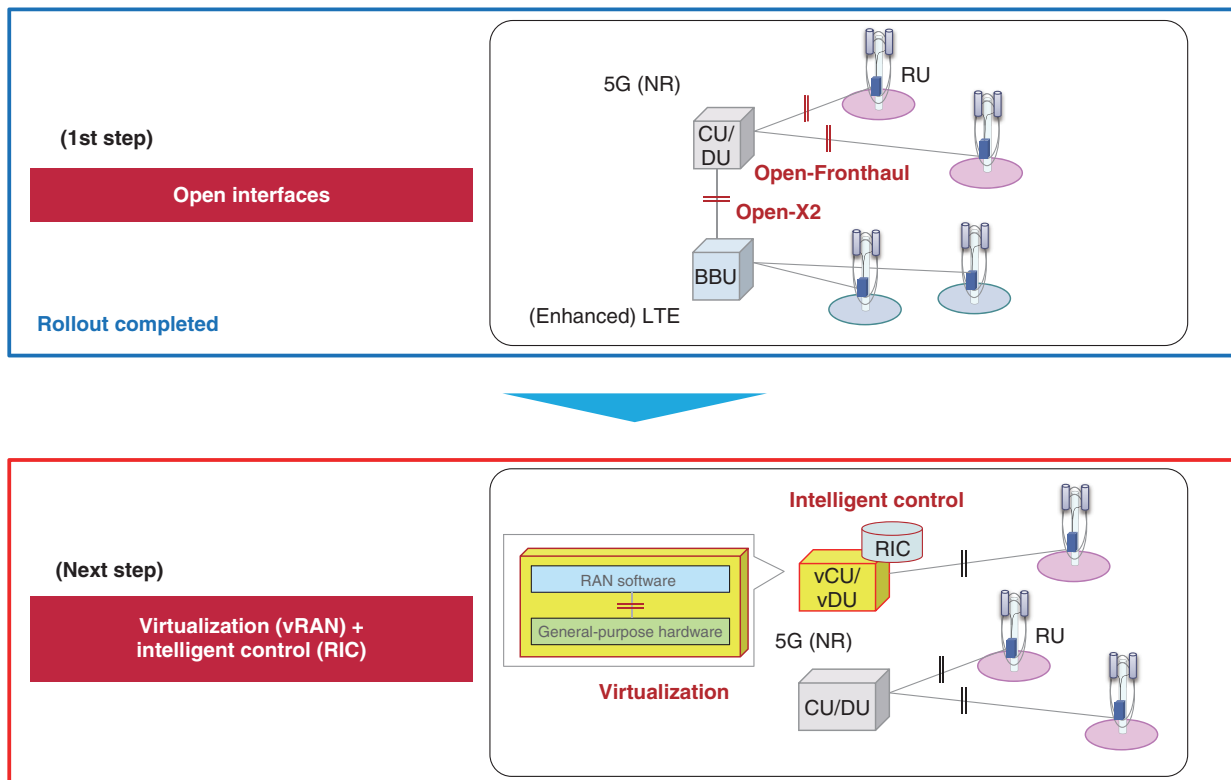


Fig. 3. NTT DOCOMO Open RAN deployment steps.

in the next section, is being set up within the 5G Open RAN Ecosystem to provide multi-vendor integration testing to overseas operators who are testing and operating RAN.

(3) Other issues

Costs, automation, and equipment rollout are also problems in Open RAN, and NTT DOCOMO solutions to these problems are described in other feature articles in this issue [3, 4].

5.3 Sharing of Open RAN testing environment

As described above, using multi-vendor products means that products must be appropriately selected and integration testing conducted. However, test cases increase as the number of products and interfaces increases, and having each operator prepare an environment tailored to its testing needs is inefficient.

Against the above background, NTT DOCOMO set up an open testbed in Japan as part of the 5G Open RAN Ecosystem. One of the main functions of this testbed is enabling overseas mobile operators to remotely control it as if it was a testbed in their own laboratories. This testbed can be connected to an

operator’s core network^{*14}, making it easy to conduct tests of vRAN equipment using products from multiple vendors. Thus, an operator can dramatically decrease the time and costs incurred by testing, so it is thought that this testbed can contribute to the timely deployment of Open RAN. The testbed began operation in summer 2021. Products from 5G Open RAN Ecosystem partners have been provided since October 2021 and testing has begun. This testbed was released in February 2022 as a shared open laboratory providing an environment for operators around the world to test vRAN while based overseas. NTT DOCOMO is using this shared open laboratory to deepen its ties with a wide range of stakeholders including other operators and to contribute to the establishment of technologies and expertise toward the early diffusion of an open network, especially Open RAN and vRAN, that can respond flexibly and rapidly to diverse needs.

^{*14} Core network: A network comprising switching equipment, subscription information management equipment, etc. A mobile terminal communicates with a core network via a RAN.

6. Conclusion

This article presented an overview of Open RAN, described the current state of the O-RAN ALLIANCE that is responsible for Open RAN standardization, and described the 5G Open RAN Ecosystem, a new NTT DOCOMO Open RAN initiative. As an Open RAN pioneer, NTT DOCOMO will continue to promote Open RAN that should be implemented for its own network as well as globally.

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